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GAS WORKS PLANT.

The Holiday season is again passed, and with it the maximum day's make in the past year has been reached by most companies. While this day brings its anxieties and cares to the gas maker, it is also a day that is looked forward to with much interest by almost all managers, and we are sure that in the case of the month just passed it has been a source of much satisfaction from the fact that it has indicated a generous increase in business.

For the last five or six years the indications of the maximum send out have not been so cheerful. A prolonged depression in general business has been clearly shown by the record of annual manufacture, and many managers have been obliged to console themselves with holding their own, even at the best, and in too many cases to record a decrease of consumption. But the pleasure of this festive time in this year has been increased, we are happy to say, for many a manager by finding sure signs of a return to the normal and legitimate development of the business, and a return to the upward movement in the amount of gas sold, which existed before the depression began.

A natural result of the dull times that have existed has been to endeavor to reduce expenses, curtail extensions, and, in fact, do nothing demanding expenditure of money that was not absolutely necessary. The careful scrutiny of the "economical member of the board" has been brought to bear on the manager in many a works until the last brick has been saved and worked over and over again, and the cost at the works has been forced down to the lowest possible point. But in many cases this is bound to be followed by a reaction; and patching, and "making it answer for now," must come to an end—for all at once, as the send-out goes up, it is discovered that extensions which the manager has foreseen, and asked for, are now actually demanded, not by the manager, but by the consumption. The forced economy has been clearly shown to have been no economy at all for every part of the apparatus has to be overstrained to meet the demands of a single week. It is a fact not at all understood by the general public that the capacity of a works must be maintained at a point to meet the demands of the business of a single week in the winter season, and yet a failure to supply at that time is more generally noticed and complained of by consumers than at any other season. An evening of festivity spoiled or disturbed by a lack in the supply of light is long remembered and cherished as a grievance not easily atoned for. Then is the time that monopoly is hooted and deprecated, and the deliverance by electric or some other light most ardently prayed for. While a man may complain of too much pressure and enormous bills at other times, when he "hardly used any light," at this time he wants the pressure and the light; and, for the time being, is willing to pay for it, more particularly if he cannot get it.

The point to be seen from all this is that there is no stand-still to any well-regulated gas company. Seasons of smaller increase may occur, but they are sure to be followed by an extension of business, and that is a wise man who puts his house in order in due time to be ready for all demands.

An economy that restricts plant below the capacity required for doing business easily and comfortably is as false an economy as that which keeps everything out of order, and in a broken down or makeshift condition, simply because it prevents the work being done in the best and cheapest way.

Now is the time for a careful overlooking of the field of operations confided to each manager, for the purpose of judging of the future wants of the establishment and making the necessary preparations for them in time.

In some works antiquated methods and apparatus are still employed, although there may not be a single part that owes the concern a dollar. Good, perhaps the best at the time they were put in, they may have been long since improved upon to such an extent that true economy should dictate their removal to the scrap heap and their replacement by new.

Benches that are retained for no good reason except that they have stood so long that a fancied respect for age seems to allow them to remain, are allowed to stand and waste heat, gas and fuel, while true economy would demand their demolition and renewal by others which can produce double the amount of gas at a largely decreased expenditure of fuel. There is no good reason why a retort of proper and convenient dimensions should not carbonize a ton of coal in a day, and a bench of nine such retorts might easily make 100,000 feet of gas each twenty-four hours.

These would make convenient units for keeping accounts. One ton of coal carbonized per retort per day, and 100,000 feet per bench each day would simplify the keeping of accounts wonderfully, and it would also reduce the size of retort houses required. And so with other parts of the manufacture—improvements in handling material, the use of mechanical

stokers, and proper methods of heating, would go far to secure a reduction in the cost and selling price of gas that would contribute more than anything else to enlarge the increase of consumption, and the total of profit to the company. Another Christmas ought to bring joy to many a consumer by a material reduction in the price of gas, and to the manager, as well, by a largely increased send out.

ECONOMY OF INCANDESCENT ELECTRIC LIGHTS.

There is no form of electric lighting as yet presented that seems to be more fascinating to many people than the incandescent lamps, so-called. That is the method that is looked upon as the one that may be as good as gas when all the little details are adjusted and arranged for its perfection. There are various "systems" of these lamps, all of which produce similar effects, and the main difference consisting in the arrangement of the parts, all of them being samples of the heating of a filament of some material to about a white heat in a more or less perfect vacuum. The expenditure of electricity for operating this kind of lamps is variously stated, by different electricians, as being from eight to ten times as great as in the "arc" lamps, or the large lights, for a corresponding amount of light.

In a thesis prepared by Mr. John W. Howell, of the Stevens Institute of Technology, last year, an account is given of some very careful tests with the best appliances of the actual results obtained with Mr. Edison's generator and five of his lamps.

The average commercial efficiency of the generator, as determined, was 0.887, or, in other words, 0.887 of the power applied to the machine was given out again in useful work. So that it would appear that the generator was a very perfect machine, and that, at the outside, there cannot be more than 12 per cent. of improvement in the generators.

The economy of the lamps was calculated by the energy consumed and the light produced. It was found in the series of tests, with lamps of different intensities, ranging from a dull red up to 40 candles, that there was a rapid increase of economy as the candle power increased, but while the economy of the lamp, *i.e.*, the consumption of current increased with the power its life was shortened, although tests were not made to establish the exact ratio. The five lamps tested were standard 16 candle lamps, and the result showed that one horse power of electricity supplied 10.65 of these lamps. But this is taken in terms of the current as it leaves the generator, and as Mr. Edison allows a loss of 10 per cent. of the electrical energy used in the lamps upon the conductors, the number of lamps per horse power of electricity generated is reduced by this much, or to 9.68 lamps. All this is in electrical horse power; but the tests made with the generator showed its commercial efficiency to be .887 of the power applied, so that we have 8.58 lamps per dynamometrical horse power. In reducing this result to the results obtained by the best steam engines the author employs the results obtained one year before, in Cincinnati, by the Commissioners of the Miller's Exhibition, which showed that 0.878 of the indicated horse power of three engines was converted into useful work, and, consequently, he finds that Mr. Edison gets 7.62 lamps, of 16 candles each, per indicated horse power.

The paper referred to is a very valuable contribution to the electric literature of the day, and is published in full in Van Nostrand's *Magazine* for January, 1882.

The Annual Meeting of the American Society of Civil Engineers.

The next annual meeting of the American Society of Civil Engineers will be held at the Society House, No. 127 East 23d street, New York city, on the 18th and 19th insts. During the past year the Society has purchased the house which it occupies, and largely increased its facilities for the comfort and convenience of the members.

It is hoped that there will be a full attendance, and as there are many members connected with the gas interest we take the liberty of urging all those gas engineers who are members to be present if possible. On the 18th, at 10 A.M., there will be a meeting for election of officers, reports and general business. A 1 P.M., lunch will be furnished at the house, and an afternoon session held afterwards. Should the business require it the meeting will be continued in the evening.

On the 19th the Society will visit some points of engineering interest about the city, including the Eighteenth street station of the Manhattan Gas Light Company, to witness the operations of the Ross stoking machinery, and the arrangements for handling material, the Hudson River Tunnel, the Brooklyn Bridge (which it is proposed to cross on foot), and various other places.

During the evening of the 19th, Thursday, there will be a reception at the Society House, with a collation for the members and invited guests. This promises to be one of the pleasantest meetings held for a long time, and every member should be present who can possibly arrange to do so.

Analysis of Coal.

It is often of great practical value to the gas engineer to know something of the qualities of a coal without an extended trial on a large scale. The chemist also is frequently called upon to give an opinion as to the value of a coal for some particular purpose, and it becomes an important question how far the laboratory experiment can be trusted to give results which shall agree, within reasonable limits, with these obtained practically. In many cases the laboratory work does very well, and where it fails, the failure may be partly due to a want of proper care in making the experiment, but very largely to the difficulty of obtaining an average sample of the coal for analyses.

As bearing upon this subject, some suggestions from Mr. L. T. Wright, on the proximate analysis of coal, which appeared in a recent number of the *Journal of Gas Lighting*, will be of interest. The proximate analysis includes the determination of moisture, volatile matter, fixed carbon, sulphur and ash.

The determination of the moisture is attended with great uncertainty, from the fact that the usual instructions to dry to constant weight often result in a partial oxidation and consequent increase in weight, and moreover the temperature at which the drying is effected is liable to alter the results. Mr. Wright considers the determination of moisture by loss of weight as unsatisfactory, and recommends that the water be actually weighed.

The volatile matter is generally determined by heating the powdered coal in a closed crucible for a certain length of time. Mr. Hinrichs says that 3½ minutes over a Bunsen burner and the same time over a blast lamp immediately afterward will give accurate results. The greatest difference between three determinations is given as 0.27 per cent. Mr. Wright did not obtain as satisfactory results by this treatment, and experimented on heating the coal until all gas ceased from issuing under the lid of the crucible, and then for a certain time longer. He finally decided on the following method—

Two grammes of finely powdered coal are placed in a platinum crucible and heated by a powerful gas flame until the gases cease issuing from the crucible, which is then further heated for one minute, cooled and weighed. The ignition is, of course, done with the cover of the crucible on, but the weighings are done without the cover for the reason that much volatile carbon adheres to it, and which without this precaution would give low results.

The ash of easily combustible coals is determined by igniting a known weight of it in a platinum crucible with access of air until all carbon is consumed. With more refractory cokes the operation is best performed by placing the powdered material in a piece of platinum foil, rolled so as to admit its introduction into a piece of combustion tubing heated to redness. Air is drawn through the tube during ignition and readily destroys the carbon.

The determination of sulphur is often the most important part of the analysis, and a great variety of methods have been suggested. Mr. Wright prefers the following as the best and simplest method—

One part of finely pulverized coal is mixed with from three to four parts of carbonate of soda (which of course must be free from sulphur compounds), and heated in a dish or crucible, at first very gently, but gradually increasing the temperature until a faint red heat is reached, at which the mass is kept for about 40 to 60 minutes. It then becomes of a white or reddish color. The mass is dissolved and the sulphur determined in the usual manner. It is recommended to employ an alcohol Argand lamp for heating to avoid possible sulphur contamination from a gas burner.

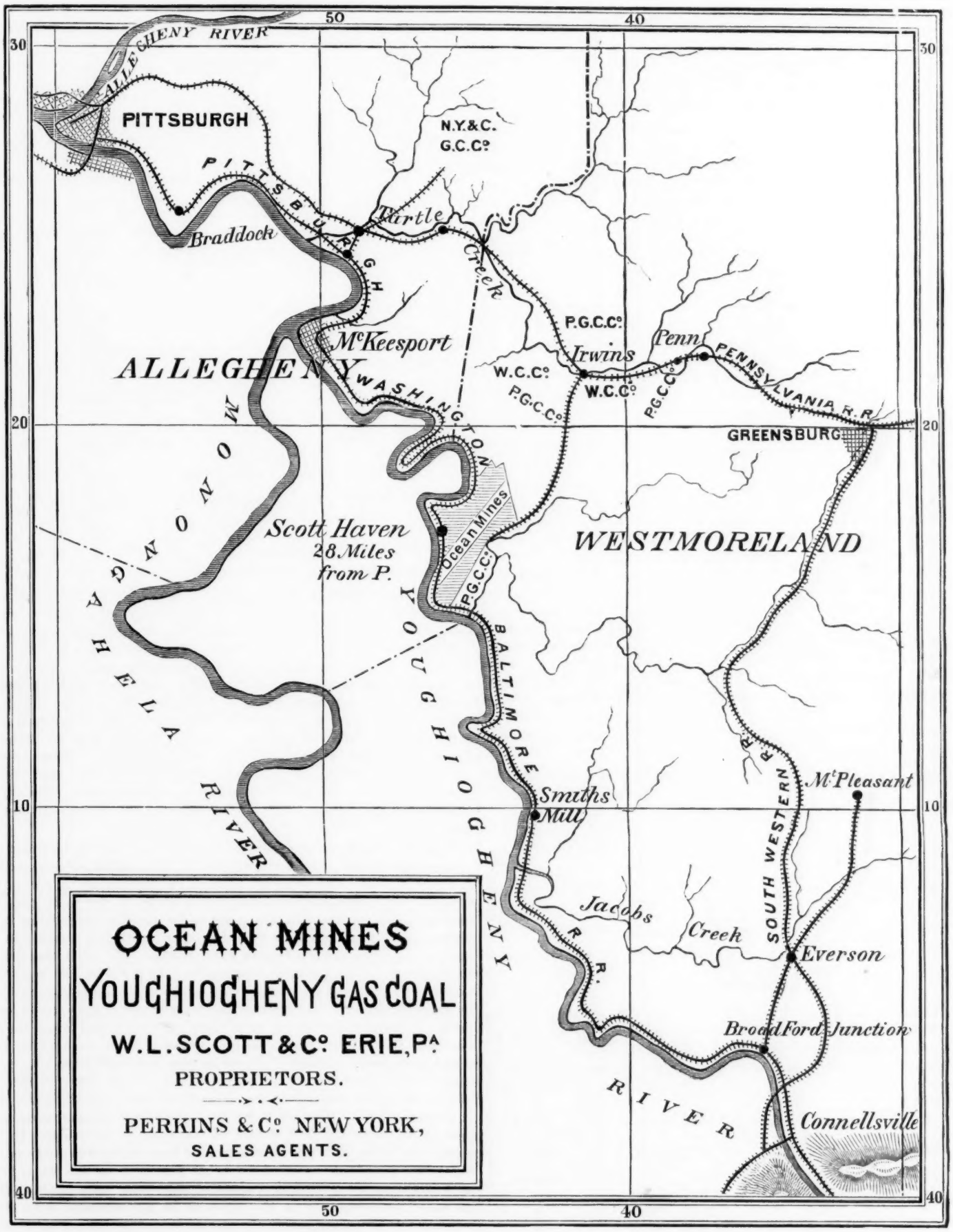
It is obvious that some sulphur compounds will be eliminated in determining the volatile carbon, others will be driven off in igniting, for the ash and others still will remain in the ash as sulphates. When it is desired to know these different amounts, three determinations are necessary; first, test of the total sulphur as already mentioned; second, the sulphur of the fixed carbon, obtained by igniting this in a tube and aspirating the gaseous products through a standard solution of iodine; third, the sulphur of the ash. The second and third if subtracted from the total sulphur will give that which passes off with the volatile carbon.

In calculating the analysis allowance must be for the sulphur, found in the volatile and fixed carbon and the ash.

Mr. Wright's gives the following analysis of Australian shale (sp. gr. 1040.1).

Water test at 100°C.		0.44
Volatile matter		77.69
Fixed carbon		5.56
Ash		15.83
Sulphur in volatile matter	—0.455	
" fixed carbon	0.48—0.012	
" ash	—0.014	
		100.00

—*Sanitary Engineer.*



MAP SHOWING LOCATION OF SCOTT'S OCEAN MINE YOUGHIOGHENY GAS COAL.

The Ocean Mines, situated in the center of the celebrated Youghiogheny Coal Field, now embrace an area of three thousand three hundred acres, giving a total capacity of *thirty-six million tons.*

The Youghiogheny coal is now accepted as the *best American Gas Coal* obtainable, and the facilities of the Ocean Mine are not surpassed by any other colliery in the United States.

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Box 3695. 45 South Street, New York City.

[From the London "Journal of Gas Lighting."]

Effect of Long Storing on the Illuminating Power of Coal Gas.

By Harold B. Dixon, M.A., etc.,

Millard Lecturer in Chemistry at Balliol College Oxford; Secretary to the late Board of Trade Committee on Photometric Standards.

In the investigation, lately concluded by the Board of Trade Committee on Photometric Standards, into the relative values of the standard sperm candle and the new standards of illuminating power proposed in its place, it was of essential importance to obtain a uniform light by which to judge the standards on their trial. For this purpose a large gasholder at the South Metropolitan Gas Works was placed at the entire disposal of the Committee by one of its members, Mr. George Livesey. It was found that after the coal gas had stood undisturbed in the holder for some weeks, it varied very slightly in illuminating power from one week to another. Variations in illuminating power were indeed found to occur in the stored gas, but these variations took place in very slow and measured periods, and not in sudden oscillations. The stored gas was therefore well adapted for the purpose of comparing the efficiency and uniformity of the standards.

As I believe but few experiments have been made on the effect of long storing upon the illuminating power of coal gas, I venture to bring forward, in the columns of the *Journal*, as not uninteresting to gas managers, the effects observed in our samples of stored gas, and to briefly indicate their causes, where they appear to me capable of explanation.

The gasholder we employed at the South Metropolitan Gas Works had a diameter of nearly 100 feet; the tank was tight, and the water in it had not been changed for several years. The holder was charged with ordinary coal gas in the month of June, 1879. It was then totally cut off from the system of the works, and connected by a 1-inch pipe directly with the testing room, the pipe passing through the roof of the holder. The illuminating power of the gas was not determined when the holder was filled.

Our tests began on the 4th of July, 1879. The mean of 14 experiments with candles taken from a packet of 21-thread candles gave the illuminating power of the stored gas as 18.4 candles; and the mean of 17 experiments with candles from a packet of 18 and of 19 thread candles gave the illuminating power of the stored gas as 17.4 candles. These experiments were made on July 4, 5, 12, and 19. No great reliance can be placed on these numbers as indicating the real value of the stored gas at that date, because the candles used were taken, respectively, from a single packet of each kind, and it was found out afterward that the mean value of one packet of candles sometimes differed considerably from the mean value of another packet of the same make.

On July 25 the illuminating power of the stored gas was determined by means of Mr. Harcourt's air-gas flame, with the following result:

Observer.	Illuminating Power of Stored Coal Gas.	Date.
H. B. D.	16.3 candles	July 25, 1879.
"	16.3 "	"
"	16.2 "	"
"	16.2 "	"
"	16.3 "	"
Dr. Odling	16.4 "	"
"	16.4 "	"
Mean	16.3 candles.	

On Aug. 8 the same stored gas was tested by two different samples of air gas. The mean of six determinations with one sample of air gas gave the illuminating power of the gas as 16.58 candles, and the mean of four determinations with the other sample of air gas gave the illuminating power of the gas as 16.62 candles. The value of the gas on Aug. 8 was therefore 16.6 candles.

Observer.	Illuminating Power of Stored Coal Gas. 1st Sample of Air Gas.	2d Sample of Air Gas.	Date.
H. B. D.	16.5 candles	—	Aug. 8.
"	16.6 "	16.7 candles	"
"	16.7 "	16.6 "	"
"	16.5 "	16.6 "	"
"	16.7 "	16.6 "	"
"	16.5 "	—	"
Mean	16.58 candles.	16.62 candles.	

On Sept. 5 Mr. W. G. Wood and myself made alternately a series of tests of the illuminating power of the stored coal gas by means of Mr. Harcourt's air gas flame:

Observer.	Illuminating Power of Stored Coal Gas.	Date.
H. B. D.	16.7 candles	Sept. 5.
W. G. Wood.	16.9 "	"
H. B. D.	16.7 "	"
W. G. Wood.	16.6 "	"
H. B. D.	16.6 "	"
W. G. Wood.	16.8 "	"
H. B. D.	16.8 "	"
W. G. Wood.	16.7 "	"
H. B. D.	16.7 "	"
Mean	16.72 candles.	

The next day these experiments were continued:

Observer.	Illuminating Power of Stored Coal Gas.	Date.
H. B. D.	16.8 candles	Sept. 6.
"	1.67 "	"
W. G. Wood.	1.67 "	"
H. B. D.	16.7 "	"
W. G. Wood.	16.7 "	"
H. B. D.	16.7 "	"
"	16.8 "	"
W. G. Wood.	16.9 "	"
H. B. D.	16.8 "	"
W. G. Wood.	16.9 "	"
Mean	16.77 candles.	
H. B. D.	16.7 candles	Sept. 7.
"	16.8 "	"
"	16.9 "	"
Mean	16.8 candles.	

From these carefully made experiments it appeared that the illuminating power of the stored gas had increased in value by half a candle in the six weeks between July 25 and Sept. 6, 1879, if the illuminating power of the air gas flame had remained unaltered. The latter portion of July, 1879, was very cold; August was also cold, but the weather was warmer than in the last fortnight of July. The end of August was warm, and the first week in September hot. It appeared more likely that the gradual increase of temperature had improved the quality of the coal gas, than that the quality of the air gas had suffered from the change. The Committee, however, thought it desirable to settle this point definitely, and to determine what effect, if any, would be produced on the air gas flame by a change of temperature greater than any likely to occur in actual working. The experiments on change of temperature are thus described in the appendix to their report:

"According to the air gas tests, the illuminating power of the stored coal gas appeared to change from 16.3 candles to 16.8 candles between July 25 and Sept. 6, 1879. This apparent increase in illuminating power is due either (1) to an actual increase, owing to the water in the tank giving up some hydrocarbons dissolved during the colder weather, and perhaps to an escape of light non-illuminants from the holder; or (2) to a decrease in the illuminating power of the air gas in warm weather. To settle this point a series of comparisons was made between the light given by the samples of air gas in the two holders, starting with the water in both holders at nearly the same temperature, and raising the temperature of the water in one of them. To warm the water a spiral of metal pipe was wound round the outside of the holder, and through the pipe a blast of steam was kept up from a boiler outside the building. The steam pipe was jacketed to keep in the heat. Immediately beneath the left hand burner there was introduced a metal worm, which was kept at any desired temperature by being immersed in a vessel of water. This vessel was kept, during the determination, a degree or so above the temperature of the water in the holder. By this means the effect of a rise of atmospheric temperature was produced, for though the gas became cooled down in its passage from the holder to the photometer, yet no appreciable amount of petroleum, once liberated from the water, could condense in the pipes or in the saturated water of the meter and governor, and before entering the burner the gas was again raised to the desired temperature.

"The two samples of gas were first compared when the holders were at the same temperature, 60° F. The water in the first holder was gradually warmed up to 75° F., while the temperature of the second remained nearly constant. After standing some time at 75°, the gas was tested against the other. The water in the first holder was then gradually heated up to 90° F., and after standing some time a fresh comparison was made with the gas in the second holder.

First Holder.

"(1) 65° F. temperature of water. Illuminating power, 16.04 mean. Rate, 0.495.

"(2) 75° F. temperature of water. Illuminating power, 16.03 mean. Rate, 0.484.

"(3) 90° F. temperature of water. Illuminating power, 16.04 mean. Rate, 0.480.

Second Holder.

"(1) 60° F. temperature of water. Illuminating power, 16. Rate, 0.527.

"(2) 59.5° F. temperature of water. Illuminating power, 16. Rate, 0.526.

"(3) 60° F. temperature of water. Illuminating power, 16. Rate, 0.518.

"The illuminating power, therefore, of the 2½-inch flame produced in the manner described does not vary with a change of temperature. We conclude from this experiment that the stored coal gas rose in illuminating power during the six weeks."

No further tests of the illuminating power of this sample of coal gas were made.

A second sample of ordinary coal gas was stored in the same holder January 29-30, 1880. Its value was not specially determined at the time, but the value of the gas then being made at the works is given approximately by the official candle-testings at the Hill street testing station for Jan. 29 and 30—viz., 16.7 and 16.6 candles. After standing in the holder undisturbed for nearly two months, this gas was tested by standard sperm candles and by Mr. Harcourt's air gas flame on 15 days between March 23 and April 6, 1880. The following table, taken from the appendix to the report, gives the illuminating power of the gas according to the mean of at least the determinations with different candles from each of ten packets of Miller's standard sperm candles, having 21 threads in each strand. In a parallel column is given the illuminating power of the coal gas according to the air gas flame on eight days between March 23 and April 6:

Value of Stored Coal Gas as given by Standard Candles.

Date.		Standard Candles.		Air Gas Flame.
March 23	Packet A	16.19		—
" 24	" B	15.26		15.90
" 25	" B			—
" 26	" B			—
" 27	" C	15.21		16.05
" 29	" C			—
" 30	" C			—
" 30	" D	15.25		—
" 31	" D			15.95
April 1	" E	15.02		15.90
" 2	" F	15.88		15.95
" 3	" G	16.87		16.20
" 5	" H	16.72		16.10
" 6	" I	16.24		16.20
" 7	" K	17.26		—
General average		15.99		16.02

The value of the stored gas at this period was therefore that of 16 candles. During the fortnight these experiments lasted the illuminating power of the gas gradually rose, till at the end of this period it was 0.2 of a candle higher than when the tests were started. During this fortnight—from March 23 to April 16—there was a small increase in the average temperature of the atmosphere.

The coal gas remained undisturbed in the holder from April 6 to June 11, 1880, when it was again tested by the air gas flame. The following were the values obtained on testing the coal gas with some air gas made from specially prepared "pentane" and with ordinary air gas:

Illuminating Power of Stored Coal Gas given by—

Air Gas from Petroleum, boiling at 32 to 33.5 deg. C.	Ordinary Air Gas.
16.0 candles.	16.0 candles.
16.1 "	16.0 "
16.2 "	16.1 "
15.9 "	16.2 "
15.9 "	15.9 "
16.0 "	16.0 "
Mean, 16.02 candles.	Mean, 16.03 candles.

The illuminating power of the gas had, therefore, not altered during the two months from April 6 to June 11.

The coal gas then remained undisturbed until Sept. 29. On this and the following seven days it was tested by Mr. Methven's burner and by the air gas flame. The mean of two determinations with each of five different Methven burners gave the illuminating power of the stored gas as 16.28 candles on Sept. 29, and the mean of two determinations with each of six different Methven burners gave the illuminating power of the stored gas as 16.16 candles on Oct. 1. I have omitted in this estimation the results given by one of the burners which differed appreciably from the rest. On Oct. 2 and the two following days the gas was tested by the Methven burners and by the air gas flame, with the following result:

Date. 1880.	No. of Burner.	Illuminating Power of Stored Coal Gas as given by Methven's Burner.		Illuminating Power of Stored Coal Gas as given by Air Gas Flame.	
Oct. 2	19	15.8		16.1	
	19	15.8		15.9	16.00 mean.
	21	16.4		15.9	
	21	16.4	16.10 mean.	16.0	
	27	16.1			
	27	16.2			
	22	16.0			
	22	16.0			
Oct. 4	22	15.8		15.9	
	22	15.7		15.9	15.90 mean.
	23	15.9			
	23	15.9			
	0	15.8	15.90 mean.		
	0	15.9			
	21	15.9			
	21	16.0			
	27	15.9			
Oct. 5	27	16.4		16.1	
	23	16.3			16.15 mean.
	22	16.2	16.24 mean.	16.2	
	21	16.2			
	0	16.1			
Oct. 6	19	15.6			
	19	15.7			

Mean of the results with the Methven standard burner on Oct. 2, 4, and 5, 16.07 candles.

Mean of the results with air gas flame on Oct. 2, 4, and 5, 16.01 candles.

From these carefully made testings it appears to be conclusively established that the stored coal gas did not suffer any appreciable loss of illuminating power between March and October—a period of six months. During this period there was a sensible loss of gas by leakage from the holder, amounting roughly to from one-third to one-half the total gas stored. From October to the end of the year 1880 the rate of loss by leakage increased considerably. In March the holder contained roughly some 350,000 cubic feet of gas, and in October rather less than 200,000 cubic feet. At the end of December the volume of gas had diminished to about 50,000 cubic feet.

On Dec. 28 and the following days the stored gas was tested by means of Methven's burner—coal gas of different qualities being employed in the test burner. Those experiments only in which the gas employed in Methven's burner varied between 15.5 and 19 candles are given in the following table:

Date. 1880.	Value of Gas Burnt in Methven's Burner.	Illuminating Power of Stored Coal Gas.	
Dec. 28	15.5	15.2	
Dec. 29	15.5	15.1	15.2
"	15.5	15.4	
"	17.6	14.6	
"	17.6	14.5	14.6
"	17.6	14.6	
Dec. 30	19.0	14.7	
"	19.0	14.4	14.5
"	19.0	14.5	
Dec. 31	16.4	14.5	
"	15.8	14.9	14.9
"	15.8	14.9	

Mean illuminating power of stored gas, 14.74 candles.

During the first week in January, 1881, a second similar set of experiments were made with different qualities of coal gas burnt in Methven's burner.

Date. 1881.	Value of Gas Burnt in Methven's Burner.	Illuminating Power of Stored Coal Gas.	
Jan. 3	15.5	14.4	
"	15.5	14.4	14.4
"	16.2	14.3	
"	16.2	14.4	14.3
"	16.2	14.2	
Jan. 5	17.3	14.4	
"	17.3	14.3	14.4
"	18.5	14.1	
"	18.5	14.1	14.1

Mean illuminating power of stored coal gas, 14.3 candles.

During the period of three months from Oct. 6, 1880, to Jan. 5, 1881, the value of the stored gas had therefore fallen from 16 to 14.3 candles. Of this loss very nearly 25 per cent. took place during the last week.

Of the two samples of coal gas stored and tested by the Committee on Photometric Standards at the South Metropolitan Gas Works, the first was observed through a period of six weeks in the summer of 1879, during which time it rose in value half a candle—from 16.3 candles to 16.8 candles; the second sample was observed through a period of over nine months, during which time its value remained practically constant from March to September, and then diminished by one and a half candles between September and January.

Apart from any slow chemical change in the constituents of the coal gas, a loss of illuminating power might occur from physical causes. The chief light-giving constituents of coal gas are olefines—ethylene and its homologues—which are soluble to a small extent in water. The volume of a gas which is dissolved in a given bulk of water depends upon its "coefficient of solubility," a quantity differing with different gases and liquids, and one which varies for a particular gas and a particular liquid with their temperature, and also upon the particular gas in contact with the liquid. When a mixture of different gases is exposed to the solvent action of a liquid, the relative value of each gas dissolved varies directly with its coefficient of solubility and with the volume of it present in the mixture. In the case of the atmosphere—a mixture of 4 vols. nitrogen and 1 vol. oxygen—the coefficient of solubility of oxygen in water is roughly twice that of nitrogen; but since the tension of oxygen in the atmosphere is one-fourth that of nitrogen, it follows that the gas dissolved by water from the atmosphere consists roughly of two volumes of nitrogen and one volume of oxygen. Supposing a quantity of water so charged were placed under the receiver of an air pump, and the pump were worked; as the tension of the gases above the surface of the water became less, the water would give out portions of the dissolved gases which it could no longer hold in solution, and the atmosphere in the receiver would now be richer in oxygen than ordinary air. From such an atmosphere water would dissolve a larger proportion of oxygen than it does from ordinary air, under the same total pressure, because the tension of oxygen in this artificial atmosphere is greater than in ordinary air. By repetitions of these processes of alternate solution and pumping, a gas continually richer in oxygen could be separated, until nearly pure oxygen was obtained. This well known principle has been applied by Mallet for preparing oxygen on the large scale for use in blast furnaces.

When a mixture of gases—such, for example, as ordinary coal gas—is passed into a holder standing over fresh water, the water immediately begins to dissolve the gases above it, and the process of absorption goes on until a balance is struck between the volume of each gas dissolved and the tension of the same gas in the holder above. If the solubility of all the gases present is identical, no change in the composition of the mixture occurs; a portion of it is merely abstracted by the water. But if the solubilities differ, a change in the composition of the mixture occurs, and it becomes poorer in gases of higher solubility, and richer in gases of lower solubility. When more coal gas, of the same composition as before, is run into the holder in place of the first charge, a fresh absorption by the water takes place, until at length all the water in the tank is saturated with the soluble constituents of coal gas. When this limit is reached no further solution takes place so long as the temperature remains unchanged. But the coefficients of solubility of most gases are not the same at different temperatures. They diminish with a rise of temperature and increase with a fall of temperature. Therefore, if at any particular temperature the water in a gasholder tank is saturated with the various constituents of coal gas, so that it can absorb no more of these gases from coal gas, a rise of temperature will cause the water to dissolve fresh portions of the gases above it. Now the olefines, which constitute the chief light-giving constituents of coal gas, are more soluble in water than hydrogen and marsh gas, which make up the greater part by volume of it. Consequently, when coal gas is allowed to stand over fresh water it loses in illuminating power by the selective absorption of the water, whereby a relatively larger body of olefines is dissolved than of hydrogen and marsh gas. When the water is saturated with olefines, it no longer exerts any solvent action on the illuminating constituents of coal gas so long as the temperature remains constant; but if the temperature of the water falls, some of the olefines are absorbed from the gas, and if the temperature rises some of the olefines are given up from the water.

In Bunsen's *Gasometrische Methoden* the coefficients of solubility of ethylene—the chief olefine present in coal gas—and of marsh gas and hydrogen for different temperatures are given as under:

Coefficients of Solubility of Ethylene in Water.

Deg. C.		Deg. C.	
0	.256	12	.174
2	.239	14	.165
4	.223	16	.158
6	.208	18	.153
8	.195	20	.149
10	.184		

Coefficients of Solubility of Marsh Gas in Water.

Deg. C.		Deg. C.	
0	.054	12	.042
2	.052	14	.040
4	.050	16	.038
6	.048	18	.036
8	.046	20	.035
10	.044		

Coefficients of Solubility of Hydrogen in Water.

Deg. C.		Deg. C.	
0	.0193	20	.0193

This table shows that water at the freezing point will dissolve one-quarter its own volume (or 25 per cent. by volume) of ethylene, 5 per cent. of marsh gas, and nearly 2 per cent. of hydrogen. At 10° C., or 50° F., water dissolves 18 per cent. of its volume of ethylene, 4.4 per cent. of marsh gas, and 2 per cent. of hydrogen; at 16° C., or about 61° F., water dissolves 16 per cent. of ethylene, 3.8 per cent. of marsh gas, and 2 per cent. of hydrogen; and at 20° C., or 68° F., water dissolves 15 per cent. of ethylene, 3.5 per cent. of marsh gas, and still 2 per cent. of hydrogen.

A change of temperature, therefore, in the saturated water of a gasholder tank from "freezing" to "temperate" would enrich the illuminating power of the coal gas by causing the water to yield up its dissolved ethylene more freely than either its dissolved marsh gas or hydrogen; and conversely, a fall of temperature in the water brings about a diminution in illuminating power of the coal gas stored above it by a larger absorption of ethylene than of the non-light-giving marsh gas and hydrogen.

The effect of aqueous solution on the light-giving hydrocarbons in a stored sample of coal gas will, therefore, be seen in a rise of illuminating power with a general rise of atmospheric temperature, and vice versa. The variations will only take place slowly, on account of the large bulk of water and its high specific heat. The loss or gain of illuminating power will be temporary and not permanent, since the absorption is merely a function of the temperature. But a permanent change in the value of the residual gas may be brought about, if a large portion of the gas in the holder is removed either when the temperature is abnormally low or abnormally high. In the former case, when the illuminating power of the gas is enfeebled by the solution of hydrocarbons in the water, if a large portion of the gas so enfeebled is removed, the remainder will receive from the water, when the temperature becomes normal, a quantity of hydrocarbon gases approaching the amount dissolved out of the larger volume of coal gas, until their return from the water is arrested by their increased tension in the smaller volume of enriched gas; and, on the other hand, if a large portion of the gas is removed from the holder during hot weather, the remainder will be of permanently less illuminating power when the temperature falls, owing to the absorbing power of the water being brought to bear on a less bulk of gas.

When a cylinder, partly filled with hydrogen, is left standing inverted in a water-trough, a gradual interchange takes place between the molecules of the hydrogen and the air—by the alternate solution of the hydrogen in the water and its escape into the air, and the solution of the air and its escape into the interior of the vessel. This interchange is a consequence of the law that the volume of any particular gas dissolved in a liquid varies with the pressure of that particular gas over the surface of the liquid. In the case supposed, the hydrogen in the interior of the vessel dissolves in the water; the solution of hydrogen so formed diffuses throughout the mass of the water, and finally some of it reaches the water exposed to the air. Here the solution of hydrogen finds itself in an atmosphere free from hydrogen, and consequently the water gives up the the dissolved gas as it would into a vacuum. In exactly the same way the solution of air passes by diffusion throughout the water until it reaches the surface in contact with hydrogen. Here the air escapes, quickly at first, as into a vacuum, and then more and more slowly as the atmosphere inside becomes more and more like that outside.

A gasholder full of coal gas must undergo a similar change—by the alternate solution inside and escape outside of the soluble portions of coal gas, and by the alternate solution outside and escape inside of the air. But this must take place exceedingly slowly when, as in a gasholder tank, but a very small portion of the water is exposed to the air, and the sides of the sunken holder form a diaphragm to a great depth between the water exposed to the gas and the water exposed to the air. I do not know whether this slow loss by aqueous diffusion would diminish the illuminating power of 200,000 or 300,000 cubic feet of gas during a period of nine months by an amount which could be detected by any known photometric method. Our experiments gave no indication of any steady loss of illuminating power, so that either the loss due to this cause was masked by variations due to other causes, or it was too small to be appreciated by the instruments employed.

It has been suggested that a variation in the illuminating power of a sample of stored coal gas might also be caused by the molecular diffusion of the gases inside the holder through minute cracks into the air, and the corresponding diffusion of air into the holder. Such an interchange is known to take place through cracks in glass vessels, but the phenomena of gaseous diffusion has chiefly been studied by means of porous diaphragms, such as plaster of Paris, artificial graphite, and unglazed earthenware. Through the minute orifices of such septa, gases find their way according to the well-known law established by Graham, that gases diffuse at a rate inversely proportional to the square roots of their densities. Hydrogen, the density of which is 1, diffuses through a porous diaphragm into a space free from hydrogen four times as fast as oxygen, of which the density is 16, diffuses through the same diaphragm into a space free from oxygen. Supposing, then, one of the iron plates in the side of a gasholder were replaced by a piece of unglazed earthenware, the constituents of the coal gas would pass through the diaphragm at rates which depend on their densities, and the oxygen and nitrogen of the air would similarly pass through the diaphragm into the holder, even when there was a considerable excess of pressure inside.

It is possible that in a gasholder cracks occur of sufficient fineness to allow this molecular diffusion to take place, and it has been supposed that the escape of hydrogen and marsh gas from the holder in greater proportional quantity than the denser light-giving hydrocarbons would more than counteract the effect of the air, which must pass the other way into the holder, on the illuminating power of the gas; and, consequently, improve its quality while diminishing its volume.

I am not aware of any experiments having been made on the effect of mixing inert gases, such as oxygen and nitrogen, with coal gas, or of extracting part of the hydrogen and marsh gas; but I have lately made a few experiments on the effect of atmospheric diffusion on the illuminating power of coal gas, which seem to show that the giving up of hydrogen and marsh gas, and the taking up of their "diffusion equivalent" of air, lower the illuminating power.

In my first experiment, a small "diffusion vessel," consisting of the porous cell of a Daniell's voltaic element, was attached by a short glass tube, fitted into a plug closing the open end of the cell, to a stopcock opening into a small gasholder, containing about 8 cubic feet. On opening the stopcock a narrow free way was left between the gas in the holder and the diffusion vessel. The gas, having been first tested by Mr. Harcourt's air gas flame, was allowed to stand with the stopcock open under a pressure of 2 inches of water. The illuminating power of the gas was tested after 2 hours, again after 4 hours, and finally after 24 hours.

Illuminating Power of Coal Gas by Air Gas Flame.

		Candles.			Candles.
After 2 hours' diffusion.	1	16.25	After 4 hours' diffusing.	7	16.1
	2	16.20		8	16.1
	3	16.25	After 24 hours' diffusing.	9	16.1
	4	15.95		10	16.1
	5	15.95			
	6	16.25			

From these numbers it will be seen that no appreciable alteration in illuminating power had occurred in the 24 hours. Owing to the narrowness of the tube connecting the holder with the diffusion vessel, the volume of the gas only diminished by diffusion an almost immeasurable quantity during the night. To increase the diffusion, the tube connecting the gasholder with the photometer was cut, and a tube of porous earthenware one inch long and one inch in diameter was inserted. By a by-pass the gas could be taken from the holder to the photometer without passing through the porous tube. The following experiments were made with this apparatus:

Illuminating Power of Coal Gas by Air Gas Flame.

		Candles.
Direct from holder	(1)	15.9
"	(2)	15.8
"	(3)	15.8
Mean		15.8
Through porous tubes	(1)	15.3
"	(2)	15.3
"	(3)	15.2
Mean		15.3
Direct from holder	(4)	15.8
Through 2 porous tubes, each 1 ft. long	(1)	14.9
" " "	(2)	15.1
" " "	(3)	15.1
Mean		15.0

From the above-named experiments it seems that by allowing coal gas to undergo molecular diffusion into the air, its illuminating power is diminished.

The passage of a gas under pressure through a small hole—such as a pin hole in a platinum plate—is essentially different in character from molecular diffusion. Gases *effuse* through a small hole under pressure at rates which vary inversely as the square roots of their densities; but a mixture of gases or different densities passes through without any separation, just as if it was a homogeneous fluid of the same density as the mixture. Therefore a hole or large crack in the holder, by which the coal gas could be forced out in a stream, would not permit any separation of the gases or any influx of air from the outside; consequently, an escape of gas by leakage would not tend to alter, *per se*, the illuminating power of the gas.

The increase of the illuminating power of our first sample of stored gas from 16.3 to 16.8 candles was therefore probably entirely due to the increase of temperature of the water in the tank and the liberation of hydrocarbons dissolved by the colder water. A slight loss of light by diffusion—aqueous and aerial—may have taken place simultaneously; serving, of course, to make the rise of illuminating power less than it otherwise would have been. I attribute the constancy of our second sample of gas from March to October to the fact that the slight loss of illuminating power by diffusion was nearly balanced by the liberation of hydrocarbons from the water; and the sudden fall of illuminating power at the end of the year to the fact that the greater portion of the gas had been removed by leakage from the holder, and that consequently when the cold weather came on, the water exercised its increased solvent action on but a small bulk of gas, and therefore abstracted from it a large proportion of its light-giving hydrocarbons before reaching the saturation point. Had this residual gas been kept unaltered in volume till the warm weather returned, there is little doubt it would have been found of the same or nearly the same illuminating power as in the previous summer.

The general conclusion to be drawn from these experiments is that coal gas may be kept in a holder over water for a period of many months without permanently suffering any appreciable diminution in value.

[From the "Journal of the Society of Arts."]

The Storage of Electricity.

By Sylvanus P. Thompson, B.A., D.Sc., Professor of Experimental Physics in University College, Bristol.

[Continued from page 10.]

Plante's Secondary Batteries.

M. Gaston Planté, to whom more than to any other experimenter the recent advances in the practical construction of storage batteries are due, very carefully re-examined the whole question of the polarization of electrodes, using different metals as electrodes, and different liquids as electrolytes, and found that the greatest effective polarization was produced when dilute sulphuric acid was electroyzed between electrodes of lead. Similar researches, though less complete, had been made before by Sinsteden, Poggendorff, Daniel, Lenz, and Saweljew, and by Edmond Bacquerel. Sinsleden had even obtained from leaden electrodes polarization currents of sufficient power to raise a thin wire to incandescence. These researches had mostly been undertaken with the view of ascertaining the cause why the currents furnished by most of the voltaic combinations then in use fell off so rapidly in strength. The result of these researches was to suggest methods of getting rid of the residual polarization and its tendency to set up an opposing counter-current.

M. Planté, however, struck out in an opposite course, and endeavored instead to find the best means of provoking the phenomenon of polarization, in order, as he expressed it, to turn to profit the secondary currents and to accumulate the energy of the battery. He was therefore led by his preliminary researches in 1860 to construct a secondary battery consisting of nine cells, in each of which two long and wide strips of lead, separated by coarse cloth, were rolled together in a spiral form, and immersed in dilute sulphuric acid. A few months later he modified this form by placing side by side in a rectangular box two series of lead plates, alternately connected together, each plate being about 8 inches long and 9 inches high. He recurred afterward to the spiral form as being more convenient, but replacing the coarse cloth by narrow strips of gutta-percha.

But the cells thus constructed were not ready for immediate action. Two clean lead plates give no current of their own; they are only intended to receive and store up what is sent into them from some external source. And at first, while the lead is bright, when a current is sent through the cell from some suitable source, such as three or four Grove's or Bunsen's cells, the separated oxygen and hydrogen gases bubble up to the surface, for the most part, leaving only a very small percentage as an adherent film

and, in consequence, yielding only very transient secondary currents. The plate of lead by which the current enters is, however, attacked by the oxygen, and becomes covered by a thin layer of brown peroxide of lead, and this film, though thin, is powerfully electro-negative toward metallic lead, and toward the film of hydrogen on the kathode plate. The cell in this condition will therefore produce a current, and in so doing the peroxide is partially reduced to the metallic condition, and assumes in its reduction a spongy, or loosely crystalline texture. If now the cell be again charged, and charged in the opposite direction, the other plate of lead becomes, in like manner, peroxidised, while the hydrogen bubbles are less freely evolved, for the atoms of gas unite as fast as they are liberated, with the oxygen of the peroxide, and reduce it to the metallic condition. Every time the charging current is thus reversed, the films of peroxide, or of spongy metal, become thicker until the lead to a considerable depth is bitten into. And every such operation increases, therefore, the power of the cell to store up in this electro-chemical fashion the energy of the currents sent into it. M. Plante who minutely describes the process of "forming" the cell, compares it to a sort of electro-chemical *tanning*. The first day, the alternate charging should be done at intervals of a quarter to a half an hour, the cell being discharged between each operation. The next day the duration of the alternate charges may be increased from a quarter of an hour to a whole hour —the day after to two hours. After repose for a week or a fortnight, the charges may last several hours; and by the end of several months, the cell will be well "formed;" after which it should, when used, be charged in one direction only, otherwise the whole thickness of the lead plates will be bitten into and transformed into peroxide.

The electromotive force thus developed in a fully charged Plante cell may be as much as 2.38 or even 2.7 volts; and as the large area and close proximity of the plates diminishes the resistance of the liquid to a very small quantity, such cells are capable of furnishing a very powerful current* for a few minutes, and their calorific power is considerable. In fact, they discharge themselves too well, and run down too soon for many purposes. A single cell ten inches high will, however, suffice to keep a platinum wire, 2 inches in length, and one-hundredth inch in diameter, glowing at a bright red heat for three-quarters of an hour. The amount of charge will, of course, depend on the size of the plates and on the degree to which the process of "formation" has been carried out. It may be charged by using two or three Grove's or Bunsen's cells, or by the current of a dynamo-electric machine. A single Grove's or Bunsen's cell will partially charge a Plante accumulator, but will not raise it to its full power, because the electromotive force of such a source is only 1.9 volts, or less than that of the cell at full power. The cells, when in good condition, will retain their charges for many days, though there is a gradual decay in the charge, owing probably to internal electrolytic convection in the liquid. During discharge the current is evolved with great constancy until quite near to the end of the operation, when there is a sudden falling-off. This effect is very remarkable, and arises probably from the conditions of internal resistance, both in the peroxide films, and in the liquids. A Bunsen battery of small size and considerable internal resistance will take some hours to charge a cell fully; while a dynamo-electric machine may fully charge it in half an hour; but the rate of discharge will be alike in each case. The secondary battery plays, therefore, a controlling part in the rate at which such actions may go on. I am inclined to think that the well-known action of a damp string in retarding sparks of a Leyden jar, is due to a similar kind of action. Another curious fact concerning Plante's accumulator is that, after having been rapidly discharged, and left to itself, it will presently yield a small residual current—a phenomenon strikingly similar to that of the residual spark in the Leyden jar. In consequence partly of these useless residual charges, and partly also because a fraction of the energy of the charging current is wasted in heat in the cell, there is a loss of about 11 or 12 per cent. between charging and discharging. M. Plante states that voltametric measurements show that of the whole current 88 to 89 per cent. is given back by the cell.

According to Mr. Géraldy a Plante cell containing 1.445 kilogrammes of lead can store 4.983 kilogrammeters of energy, being at the rate of 3.45 kilogrammeters per kilogramme, or 11.329 foot-pounds per pound.

Mr. Plante has devoted much attention to the effects produced by uniting these secondary cells, when charged, in series, so as to augment their effects. By grouping them in a box with a Müller's commutator above them he is able to charge them in parallel arc, and discharge them in series. Twenty cells will thus furnish for a few minutes an electric arc light. With a large battery of 800 cells thus arranged, M. Plante has carried out a number of fine experiments of the highest theoretical and speculative interest, and destined some day to bear fruit in practical applications. He has further devised an instrument, known as a "rheostatic machine," consisting of a number of mica condensers connected with a rotating commutator, by which they can be charged in parallel arc and discharged in series, which, when supplied by the large battery of 800 cells, yields sparks 12 or 14 inches in length, and produces effects which otherwise can only be produced by statical (frictional) electric machines, or by the use of the induction coil. He has observed, amongst a host of other wonderful things, a very remarkable case of globular discharge, the exact counterpart on a small scale of the much disputed phenomenon of globular lighting.

* The E.M.F. being 2.38 volts, and the resistance as small as from 0.12 to 0.048 ohm, the current through a short stout wire may be considerably over 20 webers —amperes.

APPLICATIONS OF PLANTE'S ACCUMULATOR.

Since 1872 the Plante cell has been regularly used for the operations of cautery. M. Trouvé, the well-known maker of electrical instruments in Paris, has brought out a whole series of little surgical appliances adapted for use with the Plante cell, including little incandescent lamps to illuminate the cavities of the body—as, for example, to aid the surgeon in operations upon the larynx—and dentists' appliances for destroying the nerves in hollow teeth. By the kindness of Professor W. F. Barret, of Dublin, I am enabled to exhibit one of the medical cells, and the various appliances of galvano-cautery adapted for use with the same. The advantage of employing a secondary cell for such purposes is that such cells may be made of a higher electromotive force and of a smaller resistance than any single cell of any primary battery yet invented.

M. Plante, in 1860, suggested that his accumulators might be usefully employed in telegraphy, instead of the voltameters with platinum electrodes as Jacobi proposed, in order to obviate the retardation in the transmission of signals, caused partly by induction and partly the residual magnetism of the electro magnets of the instruments. The opposing current set up by the secondary battery which is in the circuit, being in the contrary direction, sweeps out the residual magnetism and the residual static change so soon as the working battery is cut out of the circuit.

Another application brought out by M. Plante is to the purpose of obtaining a household light, which will serve instead of a match box when it is desired to light a candle or a jet of gas. The "Briquet de Saturne," as he has whimsically termed this new-fashioned tinder box, is merely a small accumulator charged by four little Daniell's cells, and provided with a "push," which, when pressed, completes the circuit through a small strip of platinum foil, which glows with a red heat.

At the suggestion of M. Achard, Plante's accumulators have been employed to actuate a brake on a railway train. To work a brake a great power is required for a short time. This can be done by employing large electro-magnets to move the mechanism of the brakes, the electro-magnets being excited by six Plante cells, which distribute power to a dozen different brakes. As the charge stored would last but ten days, six Daniell's cells are also added to provide a constant, though feeble, source of current to keep the accumulators charged, and during the instant when the brakes are put on, the six Daniell's add their feeble share to the total effect. More recently M. Trouvé has employed a battery of six Plante accumulators, to propel a tricycle through the streets of Paris, attaining a speed of about 10 miles per hour. The comparative lightness of the cell in proportion to the mechanical power it can evoke in a small electro-magnetic motor, giving a great advantage in this case over a small steam engine. Trouvé has also fitted a small pleasure boat with a similar apparatus. If very thin laminæ of lead—lead foil in fact—be employed to form the cells, still greater lightness may be obtained in proportion to accumulating power, though probably at the expense of durability. This possibility has tempted M. Gaston Tissandier to propose to steer, or even propel, balloons or other aeronautical vehicles by electrical means.

M. Niaudet has shown how the Plante accumulator may be utilized in naval signaling. His suggestion is to exhibit flashing electric lights of great brilliancy, but of short duration; the source being a series of accumulators which, during the intervals of darkness, are being steadily replenished by a constant battery, or by the currents from dynamo-electric machines. There seems, indeed, no reason why a complete system of signals should not be arranged for ships on the principle of the system of flashing lights, suggested by Sir William Thomson for lighthouses. And there can be no question that were such a system adopted, many collisions at sea may be saved.

Yet another advantage of the system of accumulation, as carried out by M. Plante in his ingenious grouping of the cells, with the rotating commutator described above is that with only two Bunsen cells as a source of currents, a powerful electric light can be maintained for a short time. For colleges and schools and scientific lectures, when an occasional flash of electric arc light is wanted for some temporary purpose, without incurring the labor and expense of setting up 50 Grove cells every time, an accumulating battery is of great value.

APPLICATION TO PHOTOGRAPHY.

I would also draw attention to the great value which such an arrangement offers to photographers who may desire to have at hand a source of brilliant and white light, with small expenditure of capital and of daily labor.

I mention these applications before dealing with more recent forms of accumulator, because there appears to be an amount of ignorance in the scientific world that is simply inexplicable, with respect to the magnificent researches carried on by Plantê through more than twenty years, and the variety of useful applications to which his accumulator had been put before even the fame of more recent inventions had been noised abroad—before they had even been made at all.

FAURE'S ACCUMULATOR.

In 1880, M. Camille Faure conceived the idea of constructing a secondary battery, in which, though the tedious process of "formation" by Plantè's process is modified and shortened, the ultimate result is the same, namely, to produce upon lead plates, immersed in dilute sulphuric acid, a coating of peroxide of lead, that can readily be reduced to the loosely crystalline metallic condition. This M. Faure accomplishes by the device of giving to his leaden plates a preliminary coating of red lead (minium), made up into a paste with dilute acid, and painted upon the surface. At first he adopted the spiral form of cell, the two plates being separated by felt or leather. More recently the rectangular form has been reverted to. The present mode of construction is as follows :

Eleven sheets of lead of such thickness as to weigh about 2 lbs. to the square foot are cut to the size of 12 inches by 10 inches, an ear-piece being burned on at one corner. Or six sheets are taken ; five of them being twice the above size, and folded double, in the way shown in Fig. 1. These are

Fig. 1.

painted thickly with red lead on both sides, and against each side is pressed a piece of felt, the face of which is also thickly coated with red lead ; there being about 17 lbs. of lead and 25 lbs. of red lead altogether. These sheets are placed side by side in a water-tight case, alternate sheets being connected together by the projecting flaps. The general aspect of the cell is shown in Fig. 2. The cell is filled with dilute acid ; the total weight being about 50 lbs. When thus prepared, the cells are "formed" by a process of charging by means of the current of a dynamo-electric machine, the current being sent through them for six or seven days without intermission before they are ready for use. The red lead is reduced gradually on one side to the metallic state, and on the other assumes the condition of peroxide ; but the cell does not attain its best condition for some weeks. As it is important that the electromotive force of the charging current should not much exceed that of the cells (2·38 volts), it is usual to charge a number of cells in series. The internal resistance of such cells is stated as being less than

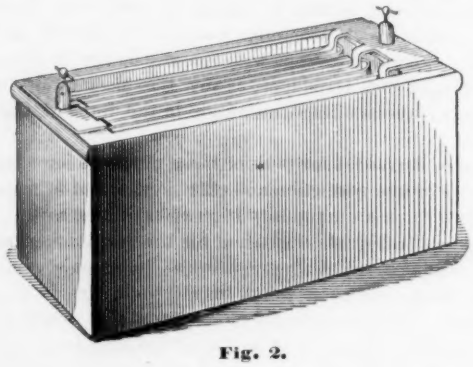

Fig. 2.

·01 ohm. The advantage of this system of construction is not confined to the saving in time of formation ; there is the further advantage of thus obtaining a much thicker film of the working substance than in the Planté accumulator ; though with the difference that the deposit of peroxide is not so regular in its structure. According to Sir William Thomson, a single cell of the spiral form weighing 75 kilogrammes (165 lbs.) can store two millions foot pounds of energy, or one-horse power for one hour. Their action is more economical, however, when the charge is not drawn upon at this rapid rate. Economy in working is found to accompany slow and regular discharge. Five or six hours is a more economical time for discharge, and then the waste is not believed to amount to over ten per cent. Sir Wm. Thomson states that the probable loss of energy in charging is 10 per cent., and in discharging 15 per cent.; but he thinks it will be advisable in practice to be satisfied with less perfect economy than this. According to Reynier a Faure cell, containing 56 kilogrammes of lead, can store 210,000 kilogrammeters of electro-chemical energy ; or at the rate of 3·75 kilogrammeters per kilogramme of lead, or 12.85 foot-pounds per pound of lead. According to M. Gèraldy, the figure is slightly less, being only 3.28 kilogrammeters per kilogramme, or 10.76 foot-pounds per lb. Such a cell, when on short circuit can, I am informed, furnish for ten hours a current of 10 to 14 webers continuously.

M. Faure is now constructing larger cells, of which, by the kindness of Major Ricarde-Seaver, I am enabled to give the following details :

The leaden plates are about 17 inches long by 12½ wide. About 50 lbs. of red lead are used ; and the sixteen sheets of lead themselves weigh about 20 lbs. The sheets which are to serve as positive electrodes are eight hundredths of an inch thick ; those which are to serve as negative electrodes are four-hundredths of an inch thick. After being painted with red lead they are folded up, first in parchment paper, and then in felt, and placed in a rectangular box, with narrow strips of indiarubber to prevent contact. Such a cell requires about 16 lbs. of dilute sulphuric acid to charge it. The total weight is about 135 lbs. for each cell. One of these cells, when placed on a circuit of small resistance, in which one of Ayrton and Perry's galvanometers was included, have the following values of current—

For 8 hours	22 webers	=	176	weber-hours.
4 "	21 "	=	84	"
1 "	20 "	=	20	"
1 "	19 "	=	19	"
Total 14 hours			229	weber-hours.

or on an average over 20 webers continuously for 14 hours. The discharg went on after this for seven hours more, when it had stopped to five webers.

DE MERITENS' ACCUMULATOR.

Another modification of the Planté accumulator has been devised by M. de Méritens. In this cell the plates of lead are made up of thin laminæ, folded one upon another like the leaves of a book, or more strictly, like the laths of a venetian blind ; the whole being soldered to a stouter framework of lead. The object of this arrangement is to secure a greater amount of effective surface. Two such compound plates are set side by side in a box containing acid ; no felt or other separating material being used. The plates require "forming," however, by a longer process than in the Faure cell. This accumulator has been highly spoken of, and showed admirable results at the late Electrical Exhibition in Paris. No examples have yet been brought to England, and I am not aware of any exact measurements having been made of their power or capacity. It is, weight for weight, far more powerful than Faure's cell ; and therefore, power for power, is of smaller bulk.

OTHER MODIFICATIONS.

In investigating the properties of secondary batteries, I have tried a number of modifications of the Planté accumulator, with varying success. I have found that almost any oxide or hydrate of lead will answer instead of red lead for the purpose of providing, as in the Faure cell, a material to be converted by a process of formation into the peroxide of lead. Litharge answers well if sufficiently finely divided before being painted on. White lead will even answer, but not so well. Litharge mixed with a small proportion of binoxide of manganese works well. The formation is rapid, but at first the electromotive is not so high as in the Planté cell. It rises, however, as the process of formation proceeds. The binoxide of manganese is not (see table) so strongly electro-negative a substance as the peroxide of lead. Its presence in the final state would lessen the electromotive force. But happily the manganese gradually dissolves into the acid when its function as an agent to assist the lead in peroxidising is fulfilled, and by changing the acid a few times it is finally eliminated. The most satisfactory cells I have yet tried were made by painting the lead plates with a coat of the brown peroxide itself, which is obtainable in commerce, though its cost is about four times that of red lead or of litharge. I find this process by far the most expeditious for making up cells ; as indeed might be expected, since it is obviously a stage towards simplification to put on to the lead plates a coating of the very substance which we desire ultimately to produce there. Examination of the plates of a cell in which the process of formation has only just begun, shows that the lead surface must itself be peroxidised and bitten into before the useful action extends to the contiguous portions of oxide or peroxide painted over it, and in some stages a yellow suboxide, probably essentially litharge, appears to be produced as an intermediate product of the reduction of the oxide at the kathode. Of this intermediate yellow product, however, I can find no trace in well-formed cells. As the reduction and peroxidation of the coating only begins where peroxidation of the lead in sheet has begun, the relation of density to maximum polarisation, pointed out in an earlier paragraph of my paper, becomes of extreme importance. Plenty of current, and yet of an electromotive force only just exceeding the maximum electromotive force of the cell, is the rule for charging in the early stages of formation. Could a spongy lead be produced by any simple

metallurgical process—like the spongy iron of Bischoff's filters—it would probably prove an admirable substance from which to form electrodes for accumulators.

COMPARISON OF PLANTE'S AND FAURE'S ACCUMULATORS.

No very reliable comparisons between the accumulators of Planté and those of Faure, or of De Méritens, have yet been made. Seeing that in each of these, when completely formed, the materials are the same—namely lead and peroxide of lead immersed in dilute sulphuric acid—the maximum electromotive force must eventually be the same in each. The resistance of a cell is simply a question of size and shape. The relative strength of current actually furnished by these cells should therefore merely vary with their dimensions. The presence, however, of the felt, and its coatings of red lead introduces resistance into the Faure cell, and as some recent determinations of M Achard show, a Planté cell will heat a greater length of platinum wire, and do its work three times as quickly as a Faure cell, whose surface is of the same amount. One would also expect *a priori* that the layers of peroxide, formed upon the electrode by the working of the current itself, should be more regular, and yield currents with greater regularity, than the artificial and more rapidly-formed layers made by painting red lead upon the surface. On the other hand, M. Faure points out that, taking cells of equal size, a larger proportion of the weight in his cell consists of the working substance. The weight of red lead placed in his cells being, for equal amounts of surface, about 26 times as much as the weight of peroxide produced by a "formation" during two years on the plates of a Planté cell of equal size. If this be so, it would imply that, although its resistance might be greater, and its rate of working slower than the Plante cell, the Faure cell would accumulate twenty-six times as much energy in an equal space. These figures require yet to be confirmed, and they are hardly borne out by the statistics of M. Regnier. Still less do they justify the extravagant pretensions that have been ignorantly set up on behalf of the enormous powers of the Faure cell—pretensions which have been angrily combated, though it is well to note that neither M. Plante nor M. Faure have taken part in this unpleasant recrimination. The Faure cell will do what the Plante cell will not, take in a greater charge, because it has a greater thickness of the working material, and it gives up its charge less rapidly. The Plante cell will do what the Faure cell of equal weight or surface cannot do—namely, produce rapid discharges in currents of greater volume; a property invaluable for the purpose of some of the applications already named.

[To be continued.]

Electric Lighting--Its Fire Risks and Their Remedies.

By Henry Morton, Ph.D.
President of the Stevens Institute of Technology.

Some very lamentable accidents have strongly directed public attention to the question of danger possibly accruing to life and property through the rapidly increasing use of electricity as a source of light, and as the actual conditions of this danger, like the true properties of the agency from which it may arise, are but little known, a brief explanation of some simple facts related to this subject will be at this time seasonable and perhaps useful.

I would propose, then, to treat this subject under two general heads, namely:

1st. The sources of danger.

2d. The conditions of their prevention, or of security.

The sources of danger in the use of the electric light are essentially two; from the conducting wires and from the electric lamps.

As long as the electric fluid, or electric energy, is conveyed by a sufficiently good conductor it is perfectly harmless, resembling a river flowing in its natural channel, and powerless to rise above its banks; it is only when some easier channel into surrounding objects is offered or some partial obstruction of a certain character impedes its regular flow that trouble may arise.

The conditions of these difficulties are, moreover, very peculiar.

Thus, for example, if two electric conducting wires, forming the outgoing and returning paths of a powerful current, are placed near each other, but are separated by a bad conductor—as, for example, when both are tacked on to a board partition wall—the current will follow the wire from end to end, with no development of heat in the same, or tendency to leave the conductor or pass into any adjacent object. If, however, between the two conducting wires we introduce some imperfect conductor, such as a small wire, some metallic dust, or a film of water containing mineral matter in solution, then a portion of the current will be diverted into this "short cut" from wire to wire and may heat the fine wire, or the metallic dust, or the wood wetted with the aqueous solution, so as to cause the ignition of inflammable matter,

Accidents of this nature have already occurred. Thus, a telegraph or telephone wire having fallen across one or more of the conductors used for street lighting purpose has been fused, or, itself escaping, has caused the fusion of finer wires connected with it.

Again, two wires, being the outgoing and return circuits of a powerful current, have been nailed side by side, without other insulation, on the same board of a floor, partition, or ceiling; and though used safely for a long time, while the woodwork was in its normal state, have developed a very dangerous activity when the wood between them was wet with dirty or impure water. In that case the water offers a circuit through which a cross current is established, which first heats the damp wood, then chars it, and finally establishes a series of minute arcs or electric sparks along this charred surface, which would soon develop a conflagration if left uncorrected.

Again, two such wires as above, insecurely attached near each other, may be brought into momentary contact and then separated, in which case an electric arc, with its intense light and heat, will be established between them. In like manner a conducting wire itself may be insecurely connected at some point, and if the abutting ends are separated slightly during use, a similar "arc" with its intense heat may be there developed.

These examples will give a fair idea of the dangers arising from the conducting wires, and they are manifestly to be guarded against by a proper separation and insulation of the wires themselves. Of this, however, more anon. At present, I would only further point out that there is no risk whatever of any heating or other injurious action arising in or from the conductor itself when an adequate one is used, as must be the case from motives of economy; since an inadequate conductor would involve ruinous expense in the use of the electric current.

Electricity is not to be regarded as a sort of fluid fire passing along the conductor; and some popular notions on this head are as absurd as were similar ones which prevailed in reference to illuminating gas at the time of its first introduction, and which caused rules to be made in some places that no gas pipe should be allowed to come in contact with any woodwork.

Turning next to the dangers which might be expected from the electric lamp, it is to be remarked in the first place that these in the case of the arc lights depend much upon the number of lamps to be operated upon the same circuit. Thus, if thirty or forty lamps are operated in series, the electromotive force of the current must be sufficient to maintain a corresponding number of arcs; and, therefore, if by any means many of these arcs are closed out the electromotive force of the current available for the remaining ones would be so excessive that their arcs might become excessively long, and even the metallic carbon holders and other parts of the lamps constitue poles between which the arc would spring, melting the metal work and establishing a very dangerous center of combustion.

To avoid this class of dangers two provisions should be made.

In the first place some arrangement in the lamp itself by which, whenever the arc exceeds certain safe limits, the current will be automatically diverted from it and carried through a good and sufficient conductor; and, in the second place, some apparatus in connection with the electric generating machine by which the electromotive force of its current should be varied automatically in correspondence with the resistance of the circuit, so that any diminution of such resistance, as by the closing out of several arcs, should cause a corresponding diminution in the force of the current generated.

Numerous contrivances for both of these purposes have been already carried to greater or less perfection and efficiency, and it is manifestly possible by such means to secure immunity from risks of this sort.

The securing of adequate insulation for the conducting wires in view of the endless ramifications of telegraphic and telephonic systems, to say nothing of the other conductors found in all buildings, is a problem of no small difficulty. One important general principle would seem to be the equal insulation of the return as well as of the machines, and the avoidance of all ground connection for any part of the circuit. Another general rule would be the separation of outgoing and return wires as far as possible from each other; and yet another, the continuous insulation of conductors, leaving no vulnerable places even where danger would not directly result from accidental contact.

Fully to discuss all the details of this subject would be impossible within the proper limits of such a note as the present, and I will therefore only say in conclusion that, with well-matured plans and skillful and intelligent provision, all these dangers may be provided against, and electric lighting may be made as safe as that obtained by gas or by candles; but without such care and judgment the use of electricity on the grand scale, whether for lighting or the transmission of power, would involve serious additions to the risks which accompany so many of the conveniences which constitute a large factor of our modern civilization.

What I have here written is but a fragment of the entire subject involved, and at some future time I hope to fill out and complete this preliminary sketch.—*Sanitary Engineer.*

Paint Removing.

A preparation, of which potash and soda are the principal ingredients, has just been introduced into England, and is said to be a perfect paint remover. Some experiments made with the preparation upon various specimens of painted wood and metal, all old samples, well painted with several coats of good oil color, were very successful. The compound, which is of a cream-like consistence, quite white, is spread over the painted surface, and after being left on a few minutes is wiped off. Its action upon the body of the paint is thorough and complete, a saponification is set up which continues, the soda is liberated, and fresh soap formed, and this process goes on, the alkali being liberated as it is wanted, till the whole of the paint is removed. Painted surfaces in about a quarter of an hour show every trace of paint cleanly removed, and the wood exposed as if it had been planed.

The action of this preparation seems to be twofold: There is first the destructive action of the applied alkali, always caustic, and next a continued sponge-like action going on—in other words, a constant and perfect causticity is maintained. The result of the preparation on metal is equally convincing. A gas meter, if exposed to the compound for about twenty minutes, has the japan removed and the bright metal exposed. Other forms of the preparation are of a weaker character and nearer to soap in their composition. They are intended to remove dirt, and their action is just the reverse of the compound already described. The preparations are liquid and are soluble in water, and their cleansing power upon cloth of an unmistakably greasy and dirty character is said to be almost magical. For delicate carvings and fabrics of all kinds these solutions are adapted, and their use by restorers, decorators and others will be highly esteemed. The modification of the solution for cleaning cloth is well adapted for restoring the linings of railway carriages and stuff seats of all descriptions. No scraping or erasing is necessary.

There is nothing injurious, it is said, in the preparation which can attack or injure metals or cloths, they all produce a minimum action on brushes which is a consideration, and, what is very important, color is not taken out by the use of the solutions. The price is less than that of other preparations. The "paint remover" can be easily applied by being spread over the painted surface to be removed. It is sold in 5 lb. tins, at 2s. 6d. each.—*Oil and Drug News.*

A New High Power Burner.

Mr. J. N. Douglass, Engineer-in-Chief to the Trinity Board, has invented a high-power burner of remarkable simplicity and efficiency. It is suitable for all sizes of burners, from the small flame required for lighting apartments, to the great blaze, resembling a miniature blast furnace in some of its capabilities, adapted for first-class light house lanterns. The largest example yet constructed is, we believe, nine inches in diameter, and is made of six concentric rings. For it should be stated, to begin with, that Mr. Douglas's burner is a multiple Argand, of rings varying in number, according to the size of the apparatus, from two to six or more. These rings are made of considerable depth, so as to form annular cylinders; and are arranged to project in steps above and below the horizontal line, the inner ring being highest above and lowest beneath the flame of the outer ring. The rings are all served by separate supply-pipes with valves, an arrangement which gives great control over the intensity of the flame. Air passes up through the spaces between the rings, which, being all of metal, conduct a considerable portion of heat downwards, and thus heat the air on its way to the point of combustion. The essential part of the invention, however, lies in the application of several tiers of curved air deflectors around the exterior of the flame, as shown in the illustration already given in our "Register of Patents," (*ante*, p. 270). These deflectors are made with different grades of curvature, and deliver a multiple blast of air, of which the inner and least deflected portion is hottest by contact with the lower part of the ring, against the flame in such a way as to drive the lower part of the outer flames inwards at an angle of about 45°. The flame is therefore strongly compacted, and at the same time exposed to a large amount of air, and the result is a most intense combustion, attended by a brilliant white radiance, showing to some observers a faint trace of violet, so elevated is the temperature attained. The shape of the flame, when all the rings are alight, is therefore that of a compact cylinder, with a somewhat extended base. It is one of the characteristics of this burner that the chimney, which is a continual source of trouble and expense with ordinary Argands, is here kept so cool by the influx of a rush of air, that, although it practically rests on the topmost deflector, it may with impunity be touched by the hand, the flame being blown inwards and away from it. A most important result of this action is the cleanliness of the chimney, which scarcely requires wiping once a week. Mr. Douglass has now a chimney in use with a 600-candle burner, which is as good as when new, four months since.

The performance of these burners is very remarkable. Although still in what might be called an experimental state as regards the structural arrangements, a 6-ring burner, 5 inches in diameter over all, and of 600 candle nominal power, developed an illuminating power, as measured by a photometer, from the Gaslight and Coke Company's common gas, of 6.5 candles per cubic foot. Another and much smaller burner, giving about 80-candle power maximum, developed a power of 5.7 candles per cubic foot. Mr. Douglass is also able to develop a minimum of 5 candles per foot with the same quality of gas in the smallest burners which he has yet made. A large burner, of 1600-candle power nominal, finished but not yet tried, is expected to develop from 7 to 8 candles per foot.

These figures speak for themselves, and must be accepted as proving that by simply manipulating the air currents, without anything of the confessed complication of the Siemens regenerative burner—in a burner, indeed, of remarkably simple and cheap construction—Mr. Douglass has achieved a phenomenally high duty from common gas. Mr. Douglass's burner is an Argand, but free from some of the greatest inconveniences of the Argand, while retaining its unequalled advantages. The combustion of the gas is of course perfect, and the design of the entire apparatus lends itself readily to the construction of ventilating pendants for apartments, in which there is a very wide field of utility awaiting a reliable appliance.

It should be stated that Mr. Douglass uses a modification of the burner for oil lamps, and recently, at the Trinity House, a good opportunity was afforded to a number of gentlemen interested in matters of artificial lighting to observe the action of the apparatus in direct comparison with a burner of the same size, but of the old simple Argand pattern. Two oil lamps were fitted in the foci of similar parabolic reflectors at two extremities of a long gallery, one being of the new design. The difference between the power of the two burners, although the wicks were of the same diameter in each, was very noticeable. In fact, the new pattern gave twice as much light as the other, and of a marked superiority in color. This is as conclusive evidence as can reasonably be required to show that whatever class of material is burnt, the laws of illuminating intensity with relation to air supply are the same; and that Mr. Douglass has succeeded in designing an arrangement which conforms, with great practical advantage, to a fixed theoretical necessity.—*Journal of Gas Lighting.*

The Electric Light in Boston.

To the Editor of the Transcript:

The lamp department at City Hall, perhaps more than any other, has been distinguised for its economic and efficient management.

The aim of the committee has been to get along with the least possible amount of light that would satisfy the public, at the least possible cost. Suddenly the policy of the committee is changed; the distinguished chairman of the committee believes in greater illumination, and proposes to place in the streets lights of 2,000-candle power.

Previous to 1879 the committee reduced the size of the burners to 3 feet per hour. The superintendent of lamps, in his last report, informs us that the 4-feet burners were restored on "the petition of a large number of citizens," and the committee would not assent to the change until they had obtained from the gas companies a large reduction in the price of gas—the Boston Company contracting for three years to furnish it at the low price of $1.50 per 1,000 feet.

It is proposed to light a few of our squares with the electric light. This may be very well, even at an increased cost, but sometimes these small beginnings lead to very grave results, and before proceeding further it will be well to count the cost.

Nobody has a right to complain at the manner in which our streets are now lighted; there is ample light, the lanterns are kept clean and bright, and there is no danger to life or limb in any street or lane in the city. There is no better lighted city in the country than Boston.

It is proper to say in this connection that while the Brush light has ten or even twenty times the candle power of the present gas burner, yet for practical use one of the electric lights will not displace twenty nor ten nor even two of the gas lights; if twenty gas lights were grouped together, one electric light would be equal to them all, but the candle power of the electric light would not diffuse itself over the space now covered by two gas burners; it is a powerful light at the flame, but that power is soon lost, its rays are reflected but a short distance; it is not a diffusive light. The train house of the Providence road requires 12 electric lights, equal, we are told, to 24,000 candles; and yet it is not satisfactorily lighted. Hence it is that the Brush Electric Light Company, while claiming this enormous candle power for their lights, deem it necessary to place them on an average 150 feet apart, while the present gas lamps are 125 feet apart; and, I think, with our crooked streets, and the dense foliage in summer on our commons, and in many of our streets, 150 feet is as far apart as they can well be placed.

But without going further into a discussion of the merits of the electric light, I propose to compare the cost of the same with the present method of lighting.

The Brush Light Company offer to furnish their lights for 65 cents each per night, and place them 150 feet apart. In one mile there would be 30 lights, which would cost for each $237.25 per annum, and for the 30 lights $7,117.50.

There is now an average of 36 gas lights covering the same distance, which the superintendent of lamps, in his report, says cost $28.89 each per annum, and, for the 36 lights, $1,040.04. This, then, is the difference in cost between the present method of lighting one mile and that of electricity—$1,040.04 against $7,117.50.

Let us now see what the difference would be should the electric light displace gas all over the city proper.

The superintendent of lamps informs us in his report that there are in the city proper 4261 gas lights, costing $28.89 each, and in the aggregate $123,180.70 per annum.

Placing the electric lights on an average 150 feet apart, it will require 3551 lamps to cover the same territory, which at 65 cents each per night will cost $842,474.75.

This, then, is the difference in cost between the present system of gas lights and an entire change to electric lights—$123,180.70 against $842,474.75.

Now, although the able chairman of the lamp committee has learned a good deal of the value of the electric light since he has become connected with the Brush Company, and would fain have its effulgent rays reflect upon his manly figure as he lays down his aldermanic honors, even he, with his economic ideas, and in view of his recent laudible effort to limit the rate of taxation by statutory enactments, will advise the city government to proceed cautiously, and not in the last hours of his official career injure his creditable five years' record by recommending an indulgence in expensive luxuries. TAXPAYER.

—Boston *Evening Transcript*, Dec. 30, 1881.

The Railways of the Globe.

The publications issued by the various departments of the Prussian Government are, if sometimes rather dry, always of great public interest. One of the most interesting compilations recently given to the world is that by the Ministry for Public Works on the origin and development of the railways of the world, from their first introduction to the end of 1880. This document contains several tables on the mileage, capital invested, passenger and goods traffic, and results, of all the railways. There were completed, at the end of 1880, 215,249 miles of railways, which had been constructed at a cost of, in round numbers, £3,750,000,000. The following table gives the mileage, capital expended on construction, and net profits of railways in the principal countries of the globe for the year 1879—

	Miles open for Traffic.	Capital Expended £.	Net Profits. £.
United States	81,087	952,500,000	43,985,000
Great Britain	17,665	717,000,000	28,345,000
Russia	16,685	345,750,000	7,900,000
Germany	16,673	340,800,000	14,610,000
France	14,125	395,250,000	17,895,000
Austria	12,378	240,800,000	8,215,000
British India	9,596	123,100,000	5,370,000
Canada	6,907	74,200,000	1,340,000
Italy	5,171	100,750,000	2,540,000
Spain	4,196	50,000,000	320,000
Sweden	3,475	22,150,000	535,000
Belgium	2,488	60,000,000	2,265,000

As regards the interest paid on capital invested, the above table shows that in France the average percentage yielded was 4.53 per cent., in Germany 4.11 per cent., in Austria 3.4 per cent., in Great Britain 3.9 per cent., in Russia 2.3 per cent., in Italy 2.5 per cent. In the United States the capital expended yielded on an average a return of 4.6 per cent., in Canada only 1.8 per cent., in the British West Indies, however, 3.4 per cent. The labor involved in such a compilation as the above must have been very great and onerous, and it is to be hoped that the painstaking officials who actually, did the work will find some recompense in the knowledge that they have performed a useful task.—*Iron.*

Gas in Theaters.

The Lord Chamberlain has sent a circular to all the theaters in London, in which he says: "The theater at Vienna, which was lately destroyed, appears to have been fairly well arranged and supplied with many modern appliances for safety, but the explosion of gas on the stage extinguished the lights in the auditory. The consequent darkness added to the panic and confusion which prevented the audience from availing themselves of the means of escape provided for them. The Lord Chamberlain has already called the attention of the managers to the extreme importance of an entirely distinct and separate system of lighting for the stage and auditory. At the annual inspection of the theaters in September last this was specially inquired into, when it appeared that, almost without exception, the houses were supplied with gas from two or more mains, and that a distinct service to the front and stage could be arranged without material difficulty or expense. The Lord Chamberlain is fully prepared to acknowledge the readiness of the managers to carry out any reasonable requirements for the safety and convenience of the public, and he feels convinced that they will agree with him that the experience of these recent calamities makes it imperative that the arrangements above alluded to should be carried out in all theaters with as little delay as possible. The Lord Chamberlain must, therefore, call on them to do so, and requests the manager of the —— Theater, in acknowledging the receipt of this circular, at his earliest convenience, to state what steps he may propose to take in the matter."

Struck Dead by the Touch of an Electric Light Wire.

A fatal accident occurred on Monday at Hatfield House, the residence of the Marquis of Salisbury, to a laborer named Wm. Dimmock, in consequence of coming in contact with the wires conveying the electric current for lighting the mansion. Hatfield House is lighted with 117 lights on the Brush system, worked by an engine of 16-horse power placed in the sawmills some distance from the house; two electric wires and a telephone wire connect the sawmills with the house; for some distance they are carried on poles, and then placed along the garden wall. The deceased was at work in the garden assisting to lay a telephone wire, and was sent to ease the wire at the corner of the brickwork to prevent its getting cut. Another man heard the wires shake, and on looking round saw the deceased lying on his back, and on going up to him found he was dead. The machine was at work at the time. At the inquest the jury found that the deceased died through touching the electric wire, and appended a recommendation that there should be a stated time for working the current, and that notice should be given of it to all persons working near the wires. It is stated that, to avoid similar accidents in future, the wires would be all conveyed either underground or on poles out of reach.—*Pall Mall Gazette*, Dec. 13, '81.

The London *Journal of Gas Lighting* comments as follows upon the above case:

The death of a laborer at Hatfield House on Monday of last week, from touching a presumably uninsulated electric lighting wire, has attracted considerable attention. It is not our purpose to unduly magnify the very real dangers of strong electric currents, or to discredit electric lighting simply because it is capable of causing damage. We desire to remark on the peculiarly insidious, or rather deceptive character of the principal risk in dealing with electricity in a state of high tension. It is simply impossible that any one should discover beforehand what would be the awful result of touching a pair of harmless-looking wires, which at the time may be conveying a tremendious amount of electrical energy. Escaping coal gas gives its own warning to the senses, and all that is necessary to avoid harm in such a case is to avoid striking a light. Yet this precaution, simple as it is, has not yet been fully taught to a careless public. What, then, will serve to warn them from wilfully or heedlessly touching an electric light line wire? The recommendation of the jury in this instance was ridiculously insufficient to point the moral of such a case; but the time may be near when an electrician who, from economical motives, transmits a death-dealing force through an unprotected wire, will find reason to repent his criminal recklessness.

Explosion of a Street Lamp.

At Stratford-on Avon, on the 5d ult., an alarming explosion of gas took place in Warwick-road, resulting in the complete destruction of the large public lamp which stood in the open space near the Red Horse bowling-green. A slight escape of gas was suspected, the lights of the lamp not being so full as usual, and in order the better to discover its whereabouts, one of the corporation gas men was sent to make an examination of the lamp soon after the extra pressure was put on at the works. The man obtained a ladder, and opening the globe of the lamp examined the burners. The escape was considered only trifling, and thinking it was in the vicinity of the burners, new ones having lately been put in, the gasman applied a light underneath. Immediately afterwards there was a terriffic explosion, the lamp being shattered, and the whole fell with a tremendous crash to the ground.

Gas Stocks.

Quotations by G. W. Close Jr., Broker and Dealer in Gas Stocks.

(with W B Scott & Co.,)

34 Pine Street, New York City.

January 16, 1882.

☞ All communciations will receive particular attention
☞ The following quotations are based on the par value of $100 per share.

	Capital.	Par.	Bid.	Asked
Gas Co.'s of N. Y. City.				
Central	$466,000	50	70	75
Harlem	1,800,000	50	94	98
" Bonds	170,000			103
Manhattan	4,000,000	50	225	230
Metropolitan	2,500,000	100	160	165
" Bonds	658,000	..	107	110
Mutual	5,000,000	100	90	95
" Bonds, go'd.	900,000	1000	100	104
Municipal	1,500,000	100	103	106
" Bonds	750,000		106	110
New York	4,000,000	100	113	116
Northern	270,000	50	—	100
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	124	126
Citizens	1,200,000	20	60	63
" S. F. Bonds.	320,000	1000	105	109
Fulton Municipal	1,500,000	100	70	75
Peoples	1,000,000	10	37	42
" Bonds	290,000	.	101	104
" "	250,000	...	70	75
Metropolitan	1,000,000	100	70	75
Nassau	1,000,000	25	72	75
" Ctfs.	700,000	1000	95	100
Williamsburgh	1,000,000	50	69	72
" Bonds	1,000,000	...	98	103
Richmond Co., S. I.	300,000	50	70	75
" Bonds	40,000	—	—	—
Out of Town Gas Companies.				
Buffalo Mutual, N.Y	750,000	100	72	76
" Bonds	200,000	1000	95	100
Citizens, Newark	918,000	50	85	90
" " Bds.	124,000	—	105	10
Chicago Gas Co., Ills			125	—
Cincinnati G. & C. Co.			178	180
Consolidated, Balt.			38	39
Bonds			107	—
East Boston, Mass		25	114	120
Hannibal, Mo	100,000	100	95	100
Hartford, Conn	700,000	25	140	144
Halifax N. S	400,000	40	148	150
Hamilton, Ontario	150,000	40	117½	
Jersey City	750,000	20	155	160
Jacksonville, Ill	120,000	50	100	...
Lewistown Maine	400,000	100	—	100
Laclede St Louis Mo.	1,200,000	100	108	110
Montreal, Canada	2,000,000	100	153	154
New Haven, Conn		25	132	—
Oakland, Cal			32	33
Peoples, Jersey City		...	75	80
" " Bds.				5
Pittsfield, Mass			120	130
Rochester, N. Y.		50	70	80
" Citizens		100	30	35
Wilmington, Del.		50	174	...
Yonkers		50	30	32
St. Louis Missouri	600,000	50	250	254
San Francisco Gas-Co., S. Fr'isco Cal.			68	69
Toledo, Ohio			95	97
Troy, Citizens	600,000	100	—	—
Washington, D. C.	1,500,000	20	185	200
" Scrip	375,000	15	200	206

50 shares of Manhattan sold at auction at 226½.

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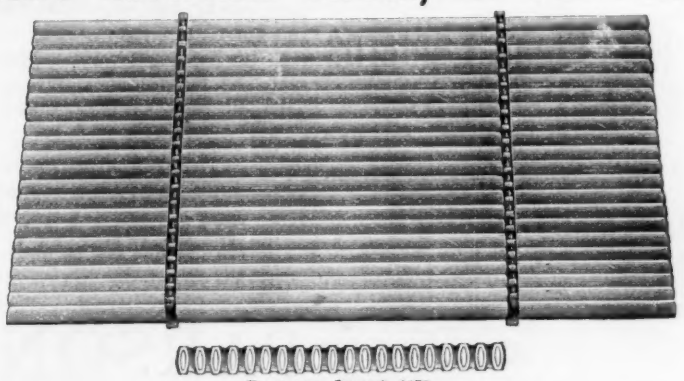

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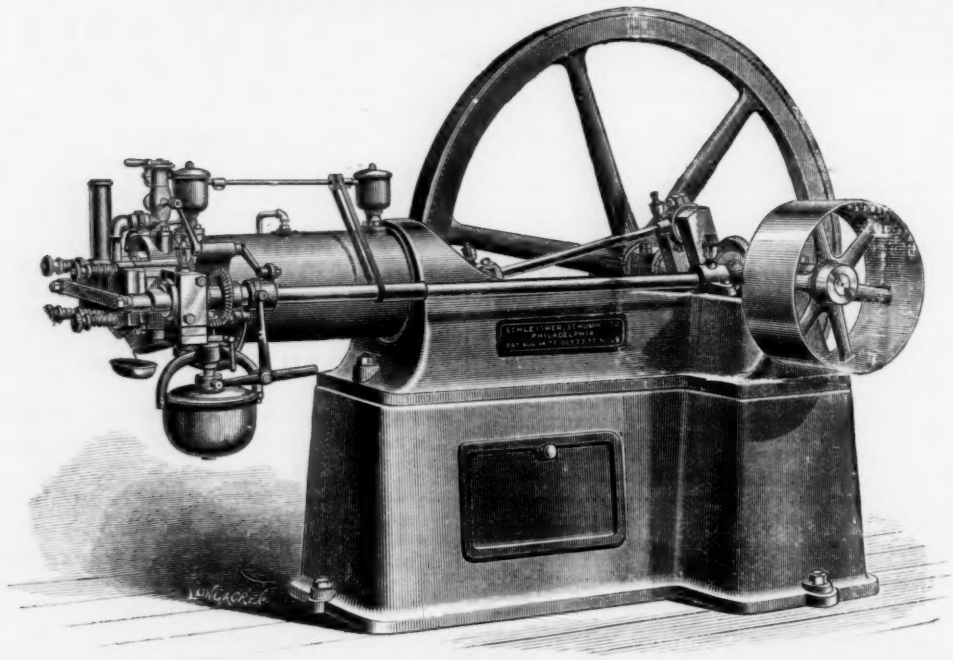

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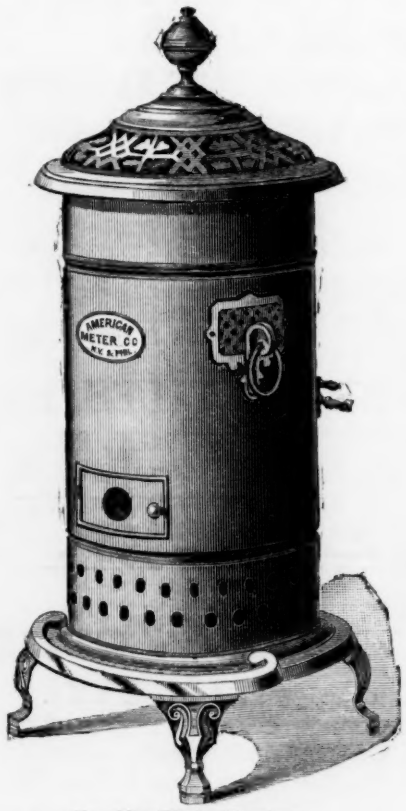

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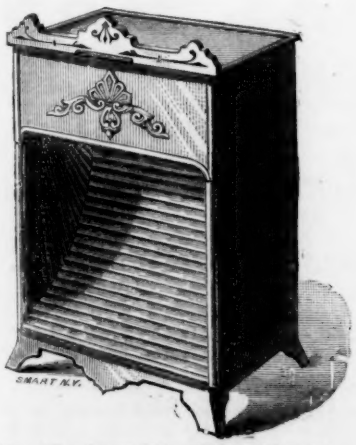

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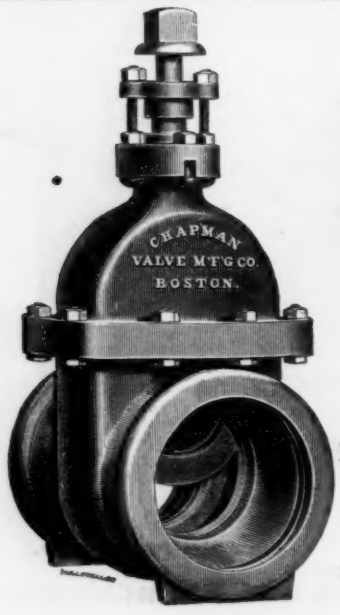

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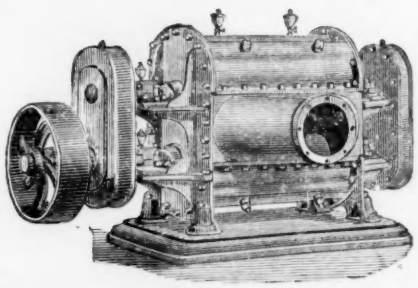

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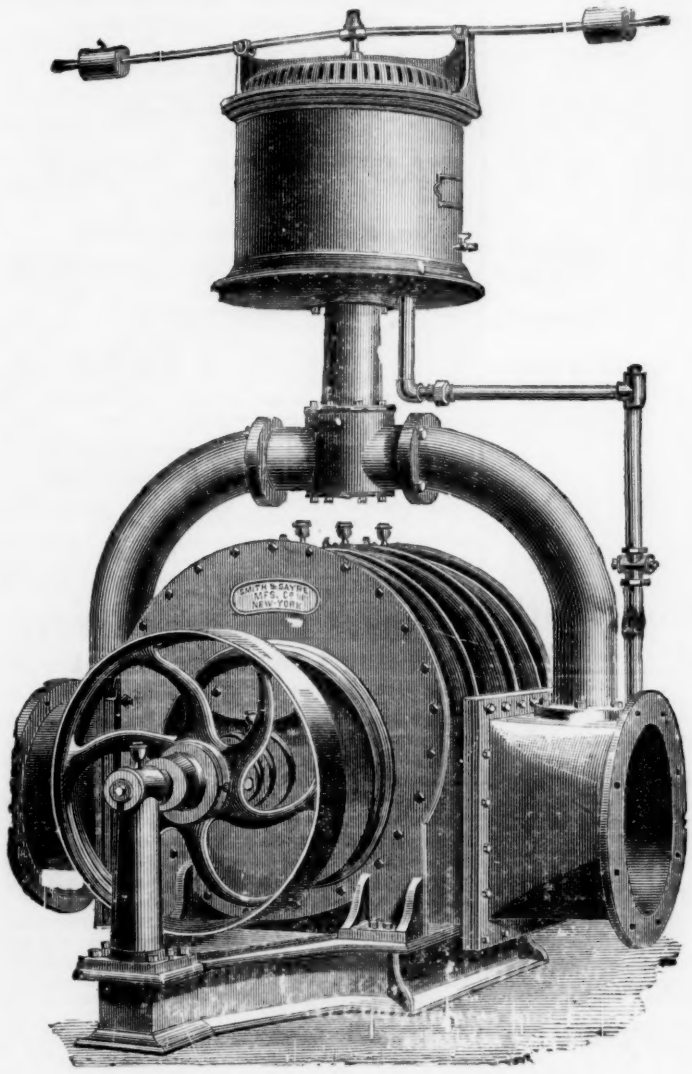

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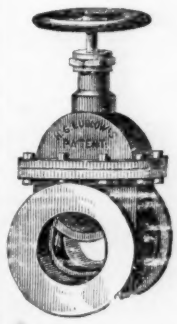

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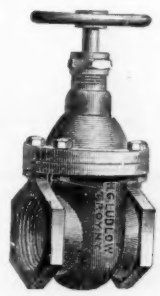

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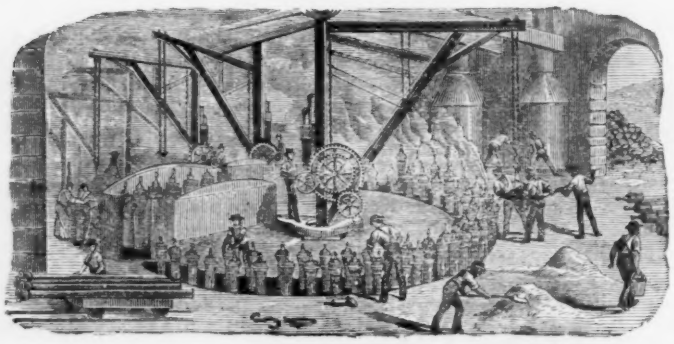

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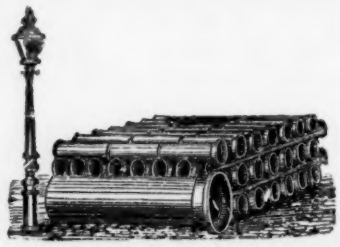

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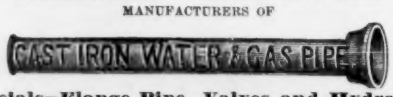

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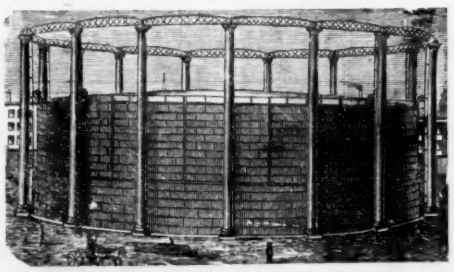

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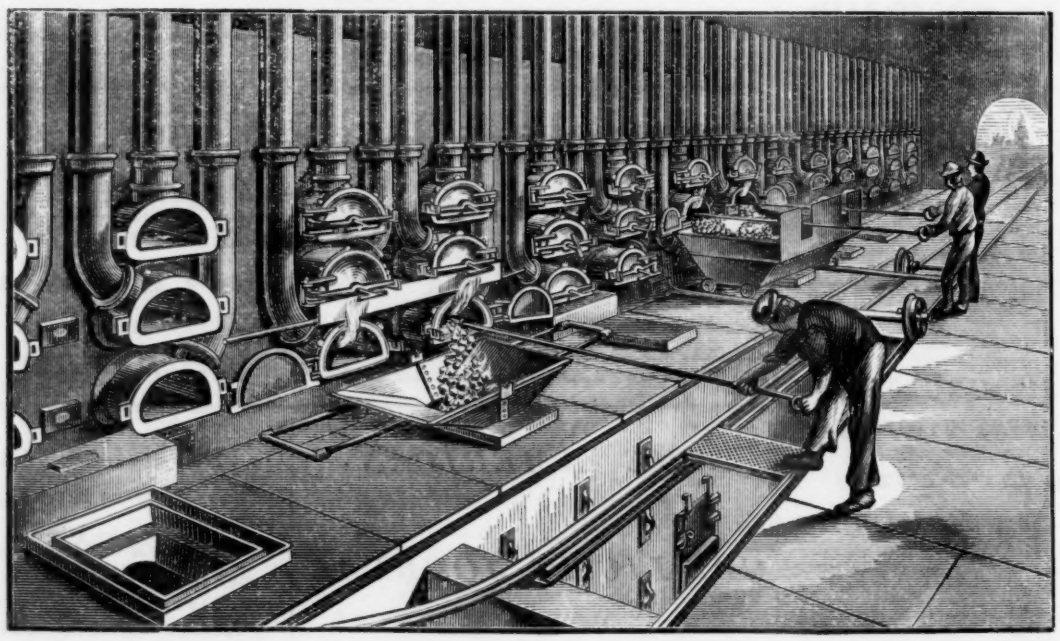

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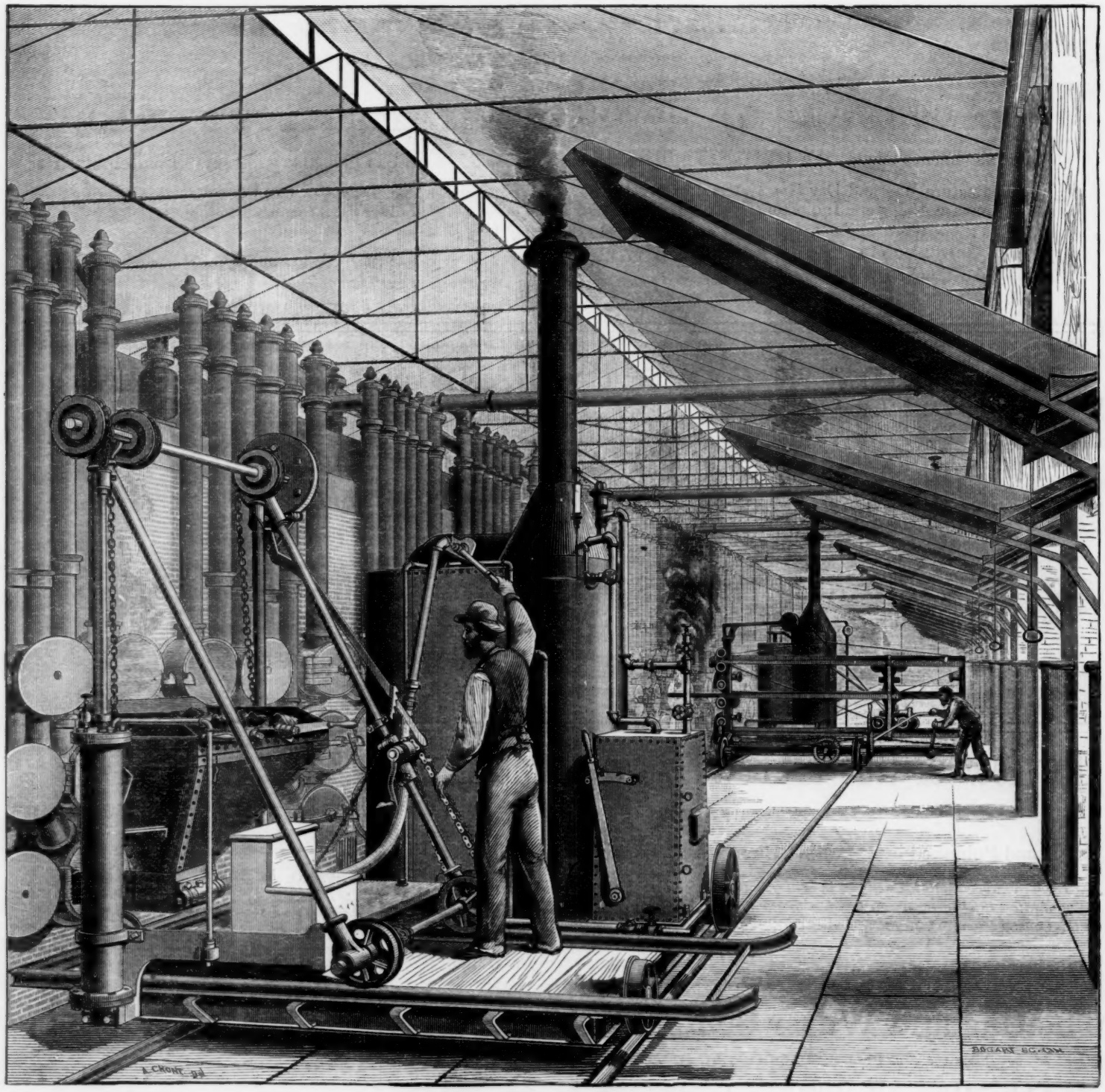

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